Brackish Groundwater: Perspectives on Potentially Favorable Development Areas & Deep Brine Injection

Governor's Water Augmentation Council
Desalination Committee

Leslie T. Katz, P.G.
Montgomery & Associates

www.elmontgomery.com
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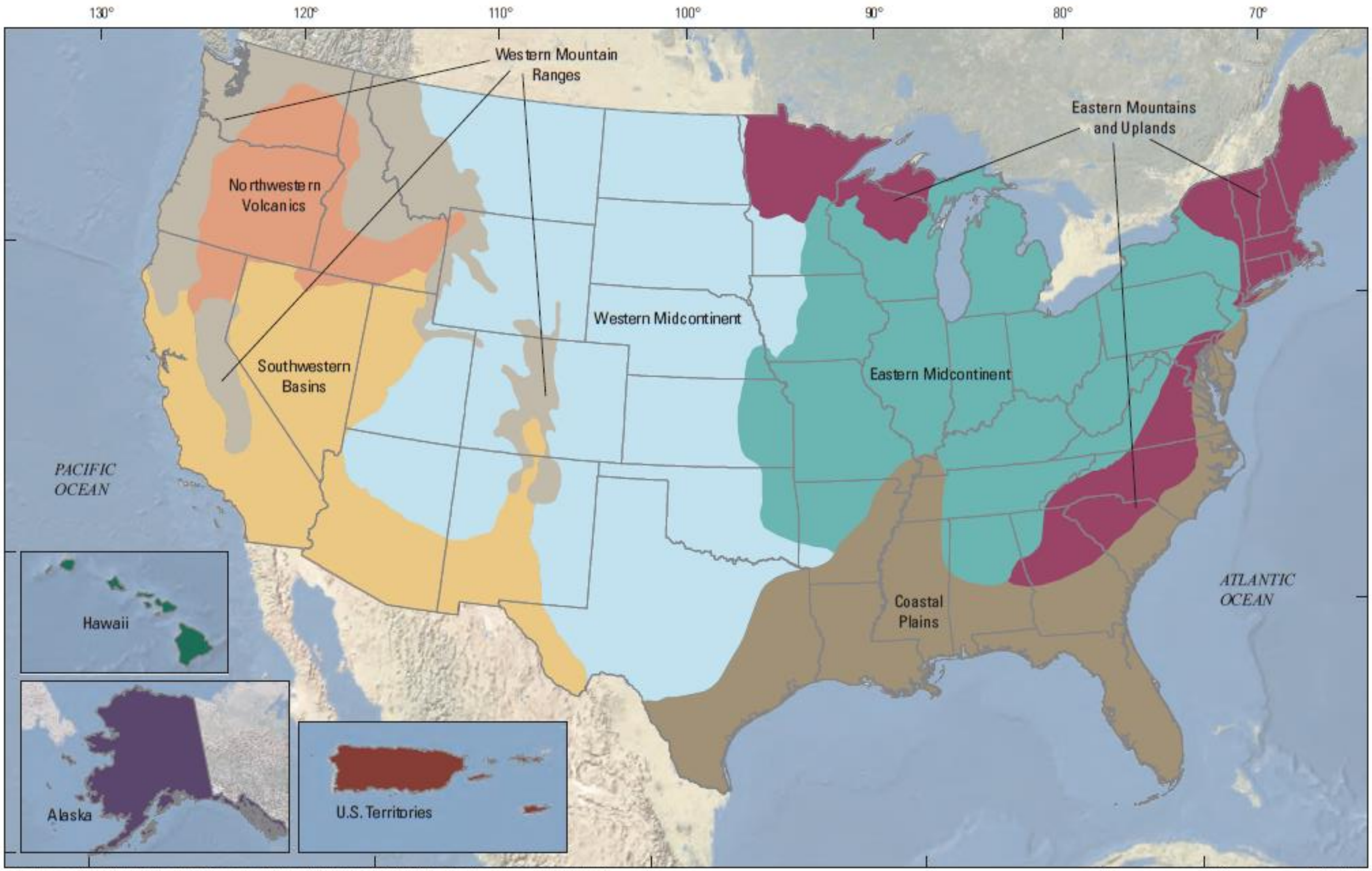
Why Look at Brackish GW in Arizona?

- Largest unallocated water resource
- More than 600 million AF of recoverable brackish groundwater in storage
- Almost 100 times current total annual AZ water use
- Desalination is proven technology and economical under certain circumstances
- Brine disposal via deep injection may be feasible and protective in some hydrogeologic settings

USGS 2017 – US Brackish Groundwater Regions



Base map modified from Esri and U.S. Geological Survey digital data, 1:2,000,000 and other scales, variously dated.
Base map image is the intellectual property of Esri and is used herein under license. Copyright © 2014 Esri and its licensors. All rights reserved.
Albers Equal-Area Conic projection, standard parallels 29°30' N. and 45°30' N., central meridian 96°00' W., latitude of origin 23°00' N.
North American Datum of 1983

USGS 2017 – AZ Brackish Groundwater

Maximum TDS in Upper 50 – 500 Feet of Aquifer

EXPLANATION

Maximum dissolved-solids concentration, in milligrams per liter

- ≤500
- >500 to 1,000
- >1,000 to 3,000
- >3,000 to 10,000
- >10,000 to 35,000
- >35,000

2008 AZ Brackish GW Study Scope

- Identify, quantify, and characterize brackish groundwater reserves using existing data sets
- Evaluate areas based on established set of criteria
- Select areas for further study based on degree to which criteria are fulfilled and absence of fatal flaws
  - Focus on potential to replace or augment CAP supplies
- Identify data gaps
- Make recommendations for future investigations in favorable areas

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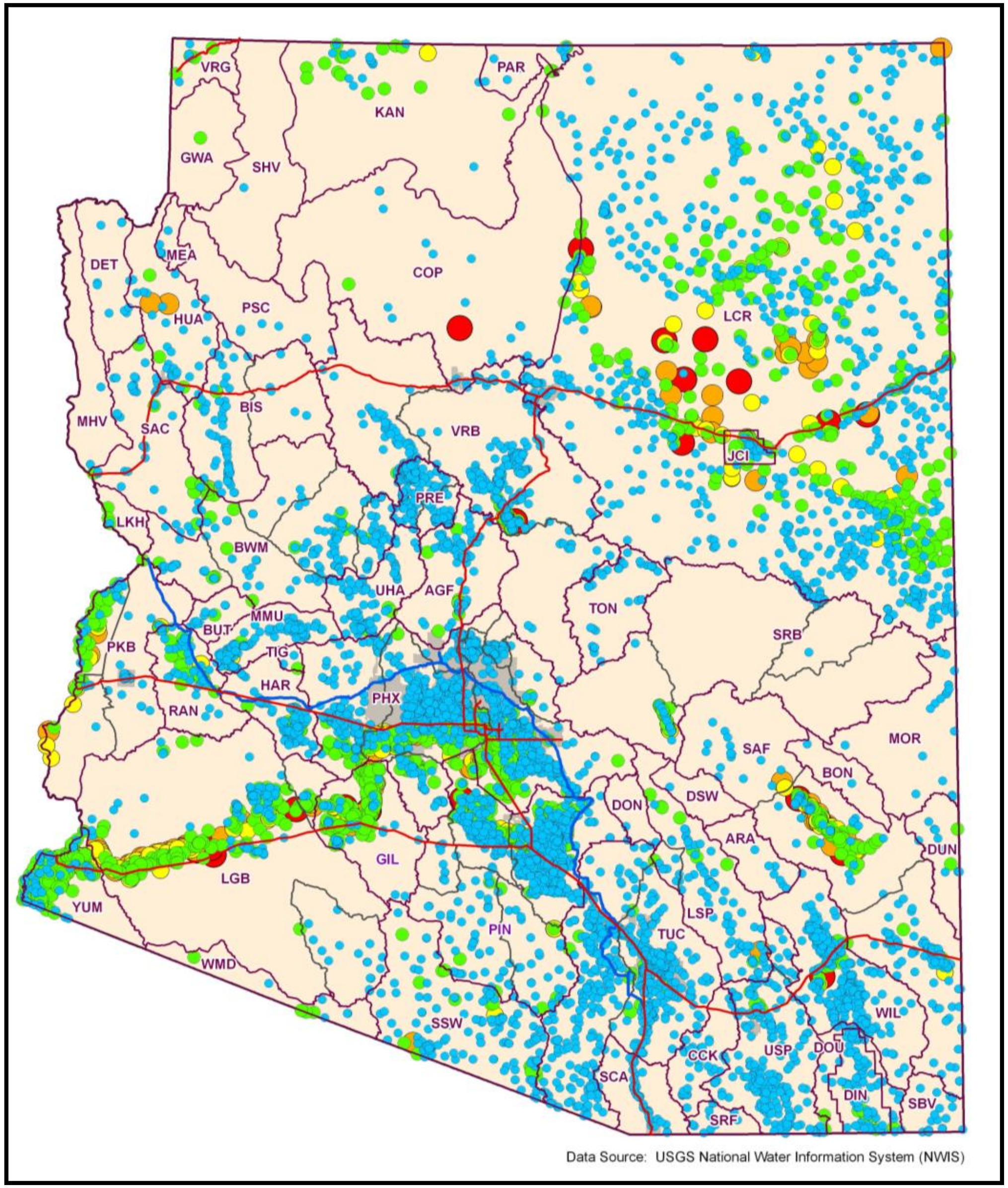
2008 Brackish GW Study Ranking Criteria

- Water quality
  - 1,000 – 10,000 mg/L TDS (~1,600 – 17,000 uS/cm)
  - Lower concentrations of constituents that make RO expensive
  - Lack of naturally-occurring or human-caused contaminants not removed with RO
- Sustainability
  - Ability to supply up to 10,000 AFY
  - Sufficient groundwater in storage above 1,200 feet
- Economic feasibility
  - Depth to water not excessive
  - Adequate well yields
  - Brine injection potential
- Environmental factors
  - No anticipated subsidence impacts
  - No adverse impacts to existing users

M&A 2008 – Brackish Groundwater in Arizona



Electrical Conductivity (USGS Data)

EXPLANATION

ELECTRICAL CONDUCTIVITY
(Estimated TDS Equivalent)

- 0 - 1,600 µS/cm (0 - 1,000 mg/L)
- 1,601 - 5,000 µS/cm (1,001 - 3,000 mg/L)
- 5,001 - 8,000 µS/cm (3,001 - 5,000 mg/L)
- 8,001 - 17,000 µS/cm (5,001 - 10,000 mg/L)
- > 17,000 µS/cm (>10,000 mg/L)
- Interstate Highway
- CAP Canal

Brackish Groundwater Area Ranking

Basin	Sub-basin or Area	Estimated Desalination Potential	Fatal Flaws
WEST SALT RIVER VALLEY	Buckeye	Most promising	None
GILA BEND BASIN	Gila Bend	Most promising	None
YUMA	Yuma Mesa and Yuma Valley	Most promising	Existing desalting plant
LOWER SANTA CRUZ	Picacho-Eloy	Most promising	None
LITTLE COLORADO RIVER	Winslow-Leupp	Most promising	None
WILLCOX BASIN	Willcox Playa	Most promising	Brackish storage unknown
COL. RVER-HOOVER TO IMPERIAL DAMS	Parker	Potentially promising	Possibly Indian water rights
LITTLE COLORADO RIVER	Concho-Petrified National Forest	Potentially promising	None
GILA-PAINTED ROCK TO TEXAS HILL	Painted Rock Reservoir to Texas Hill	Potentially promising	Small groundwater storage
GILA-TEXAS HILL TO DOME	Wellton-Mohawk	Potentially promising	Surface water particulates; other uses
HARQUAHALA PLAINS	Harquahala	Potentially promising	Generally low TDS
LITTLE COLORADO RIVER	Holbrook-Joseph City	Potentially promising	None
LITTLE COLORADO RIVER	Hopi Reservation	Potentially promising	Depth to water, excessive salinity
HUALAPAI VALLEY	Red Lake	Potentially promising	Volume of brackish groundwater unknown
LOWER HASSAYAMPA	Tonopah Desert/Centennial Wash	Potentially promising	Low TDS
LOWER SAN PEDRO	San Manuel-Winkleman	Potentially promising	Small well yields and storage
RANEGRAS PLAIN (RAN)	Ranegras Plain	Potentially promising	Low TDS
SAFFORD BASIN	Gila Valley	Potentially promising	None
LITTLE COLORADO RIVER	Cameron-Wupatki N.M.	Potentially promising	None
SAFFORD BASIN	San Simon	Potentially promising	None
LITTLE COLORADO RIVER	St. Johns-Springerville	Potentially promising	None
TUCSON AMA	Avra Valley	Less promising	Mostly low TDS
BIG SANDY VALLEY	Big Sandy	Less promising	Low TDS, small yield
DOUGLAS BASIN	Douglas	Less promising	Low TDS
DUNCAN BASIN	Duncan Valley	Less promising	Low TDS
UPPER SAN PEDRO	Sierra Vista	Less promising	Low TDS, base flow protection
TUCSON AMA	Tucson	Less promising	Low TDS (?)
MIDDLE VERDE RIVER	Camp Verde	Less promising	Small well yields and storage
VIRGIN RIVER	Littlefield	Less promising	Small storage
WATERMAN WASH	Rainbow Valley	Less promising	Low TDS, small storage
WESTERN MEXICAN DRAIN	Ajo	Less promising	Low TDS, small well yields and storage

Most Promising & Potentially Promising Brackish Groundwater Areas

Basin	Sub-basin or Area	Estimated Desalination Potential	Estimated Available Groundwater Storage (AF)	TDS Range (mg/L)		Well Yields (gpm)	Depth to Water (feet, bls)	Potential for Local Brine Disposal	Salinity Source	Subsidence	CAP Interest
WEST SALT RIVER VALLEY	Buckeye	Most promising	20,000,000	Low	High	500-2,500	<20	Evaporation	Irrigation and effluent	None	Replace CAP use
GILA BEND BASIN	Gila Bend	Most promising	25,000,000	1,000	5,000	300-4,000	75-200	Evaporation	Irrigation and evaporites	Little or none	Solar power, replace CAP use
YUMA	Yuma Mesa and Yuma Valley	Most promising	49,000,000	900	5,000	2,000-5,000	20-70	Evaporation	Mostly irrigation	None	Augment Colorado River supply
LOWER SANTA CRUZ	Picacho-Eloy	Most promising	24,000,000	<1,000	4,000	1,000-3,000	300 500	Evaporation or injection	Bedded halite and anhydrite	Existing	Near CAP canal
LITTLE COLORADO RIVER	Winslow-Leupp	Most promising	16,000,000 (brackish)	1,500	5,000	300-1,000	50-400	Nearby injection	Bedded halite	--	Navajo water rights, municipal, power
WILLCOX BASIN	Willcox Playa	Most promising	20,000,000 (brackish)	1,500	>10,000	1,000-2,000	40-300	Evaporation	Evaporites near playa and irrigation	Existing	Sierra Vista supply, power
RANEGRAS PLAIN	Ranegras Plain	Potentially promising	20,000,000	1,000	>50,000	100-3,000	30-300	Evaporation	Natural (?)	Potential	Near CAP canal
SAFFORD BASIN	Gila Valley	Potentially promising	35,000,000	400	4,000	500-2,000	100-500	Nearby injection (?)	Evaporites and irrigation	--	None
LITTLE COLORADO RIVER	Cameron-Wupatki N.M.	Potentially promising	6-10 million	400	64,000	500-1,000	200-800	Possible injection	Bedded halite	None	Little or none
SAFFORD BASIN	San Simon	Potentially promising	30,000,000	300	9,000	500-2,000	30-150	Evaporation	Irrigation	Existing	None
LITTLE COLORADO RIVER	St. Johns-Springerville	Potentially promising	20,000,000 (?)	1,500	25,000	500-2,000	50-150	Evaporation	Evaporites (?)	None	Little or none

Areas for Further Study

- Buckeye Area
- Gila Bend Basin
- Yuma Mesa and Yuma Valley
- Picacho Basin
- Winslow-Leupp Area (Little Colorado River Basin)
- Willcox Playa Area (Willcox Basin)

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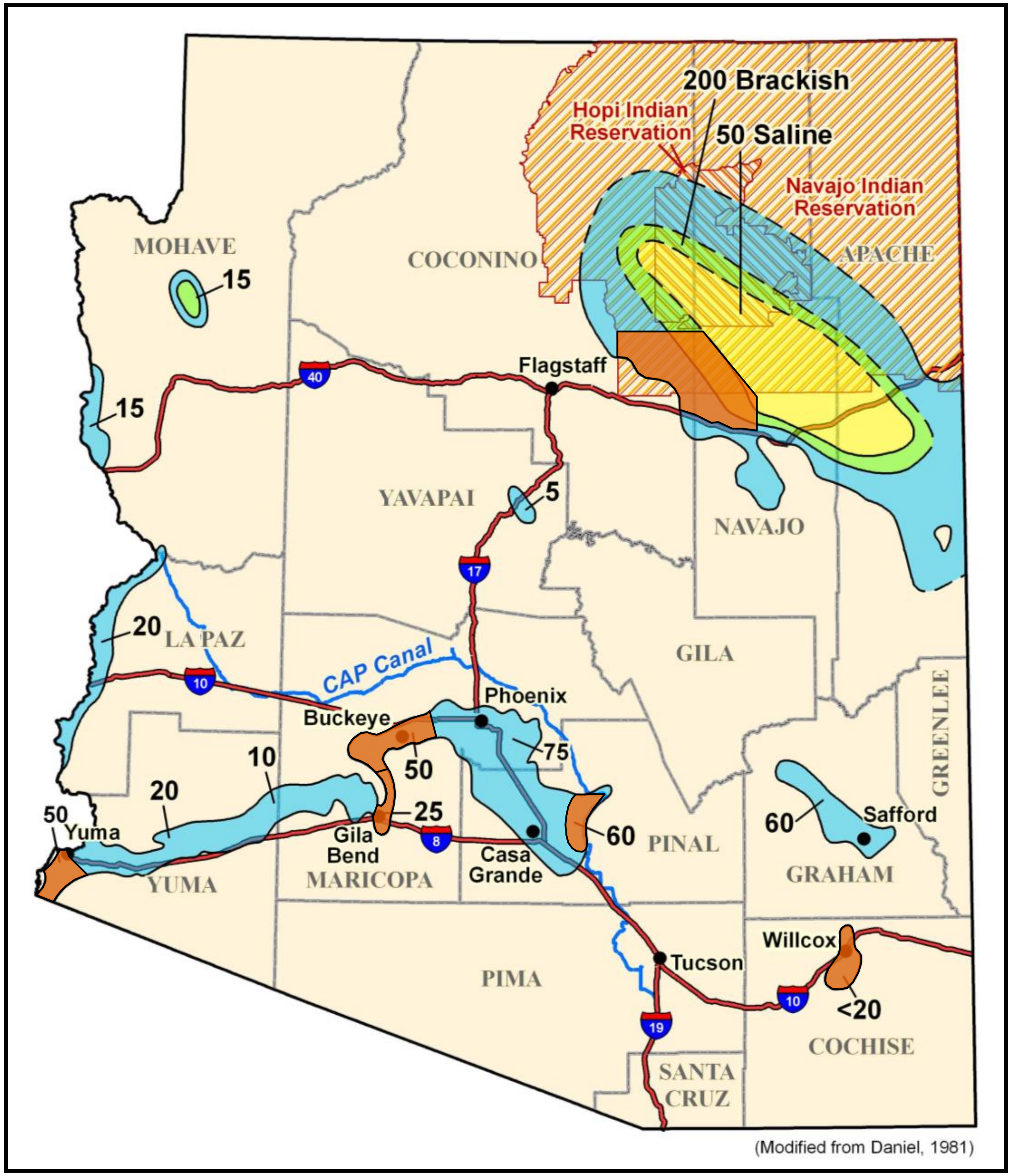
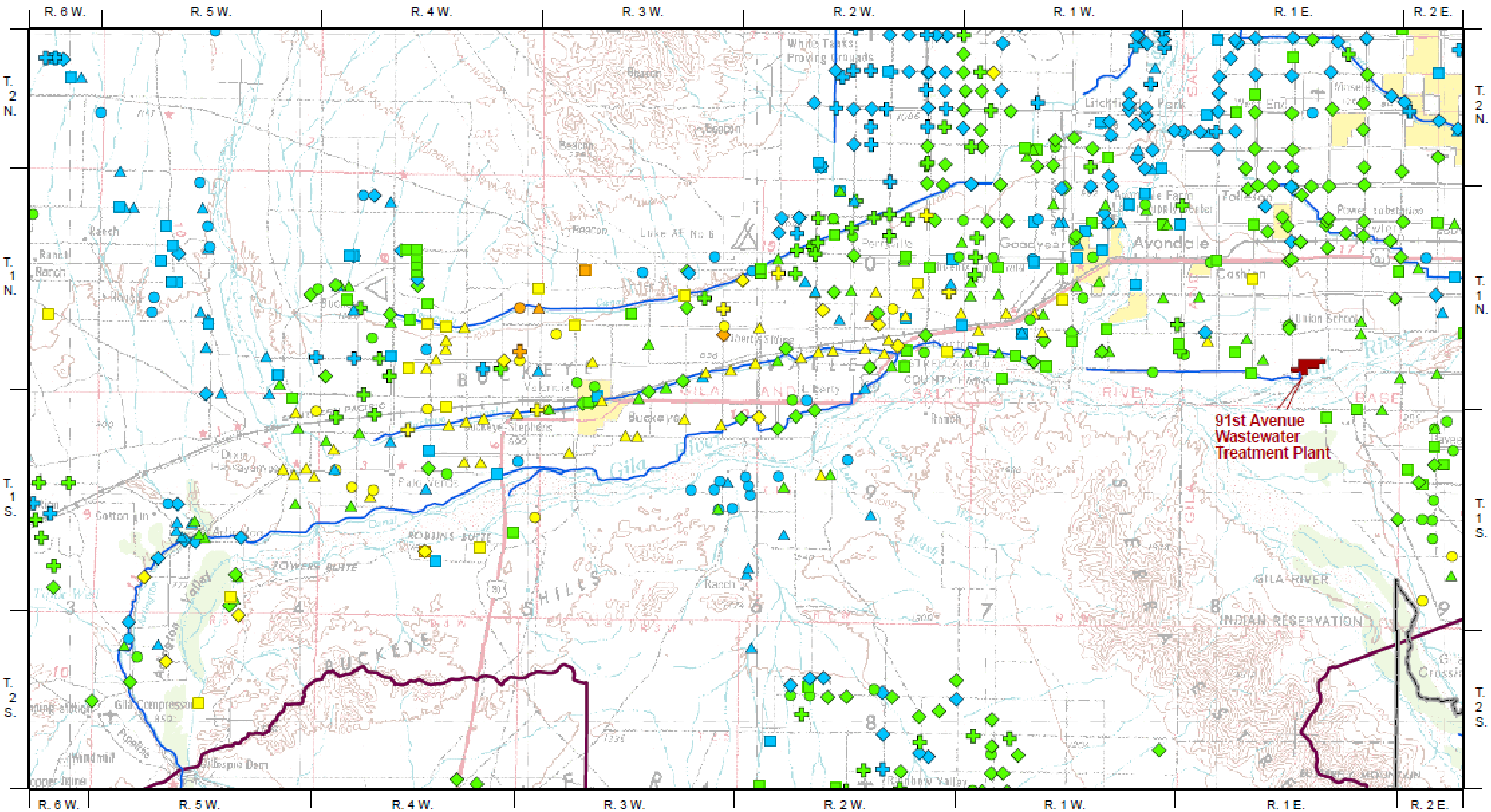
Areas for Further Investigation



- **Buckeye Area**
- **Gila Bend Basin**
- **Yuma Mesa / Yuma Valley**
- **Picacho Basin**
- **Winslow-Leupp Area**
- **Willcox Playa Area**

EC in Buckeye Area



Data Source: ADWR Groundwater Site Inventory (GWSI)

EXPLANATION

WELL DEPTH (feet)		ELECTRICAL CONDUCTIVITY (Estimated TDS Equivalent)
○	0 - 100	0 - 1,600 µS/cm (0 - 1,000 mg/L)
△	101 - 300	1,601 - 5,000 µS/cm (1,001 - 3,000 mg/L)
□	301 - 500	5,001 - 8,000 µS/cm (3,001 - 5,000 mg/L)
◇	501 - 1,000	8,001 - 17,000 µS/cm (5,001 - 10,000 mg/L)
✚	1,001 - 5,000	> 17,000 µS/cm (>10,000 mg/L)
▽	Well Depth Unknown	

Buckeye Area Pros / Cons

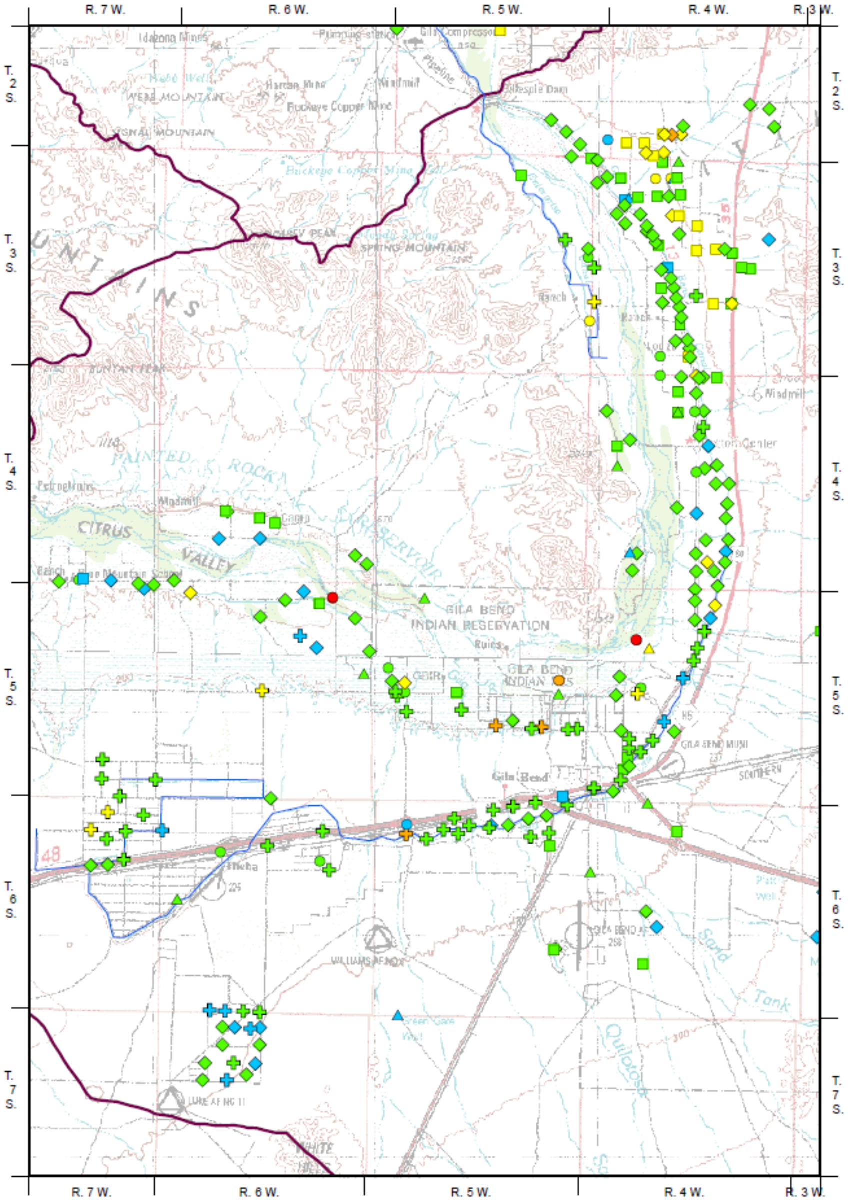
Pros

- Large area of groundwater in optimal TDS range
- Coincides with water logged area
- Current and anticipate demand for fresh water supplies
- Multiple sources of TDS

Cons

- Future land use changes may affect brackish supply
- Groundwater chemistry (Ca, Mg) may pose challenges for desal
- Potential presence of pesticides and pharmaceuticals
- Brine disposal may be problematic

TDS in Gila Bend Area



EXPLANATION

WELL DEPTH (feet)

- ○ 0 - 100
- △ 101 - 300
- □ 301 - 500
- ◇ 501 - 1,000
- ✚ 1,001 - 5,000
- ▽ Well Depth Unknown

ELECTRICAL CONDUCTIVITY (Estimated TDS Equivalent)

- 0 - 1,600 µS/cm (0 - 1,000 mg/L)
- 1,601 - 5,000 µS/cm (1,001 - 3,000 mg/L)
- 5,001 - 8,000 µS/cm (3,001 - 5,000 mg/L)
- 8,001 - 17,000 µS/cm (5,001 - 10,000 mg/L)
- > 17,000 µS/cm (>10,000 mg/L)

Gila Bend Area Pros / Cons

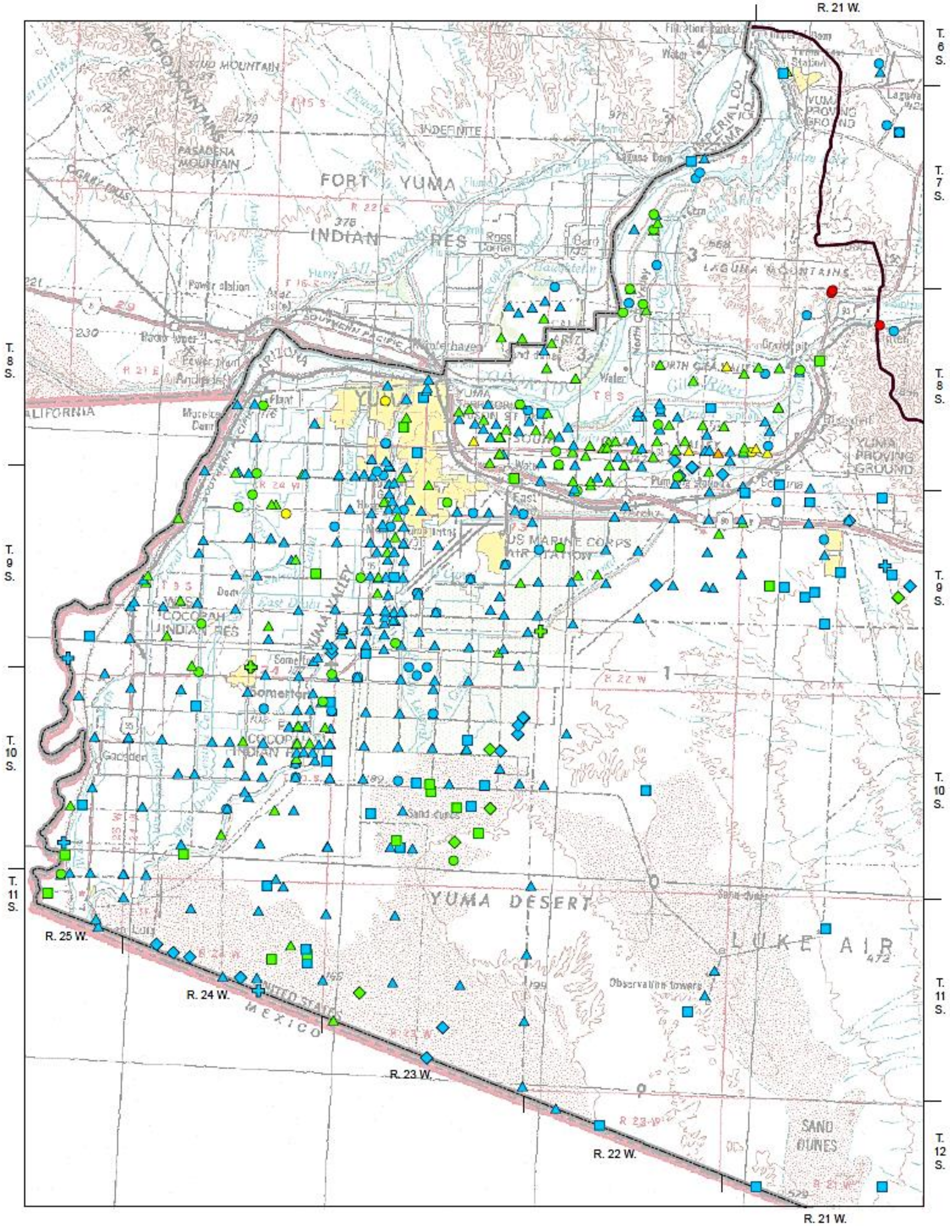
Pros

- Large volume of groundwater in storage with TDS concentrations in optimal range
- Water quality very consistent laterally/vertically
- Low Ca concentrations
- Recharge from runoff events and wastewater flows
- Irrigation demand and potential demand for solar power plant

Cons

- Potential presence of pesticides and pharmaceuticals
- Brine disposal may be problematic

EC in Yuma Mesa / Yuma Valley



EXPLANATION

WELL DEPTH (feet)		ELECTRICAL CONDUCTIVITY (Estimated TDS Equivalent)	
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✚	1,001 - 5,000	●	> 17,000 µS/cm (>10,000 mg/L)
▽	Well Depth Unknown		

Yuma Valley /Mesa Area Pros / Cons

Pros

- Long-term, sustainable supply of brackish groundwater
- Pumping could partially mitigate water logging
- Anticipated long-term demand for agricultural supplies

Cons

- Administration of Colorado River accounting surface during drought could be problematic
- Recent water quality data is lacking and can't rule-out issues for desal
- Brine disposal may be problematic

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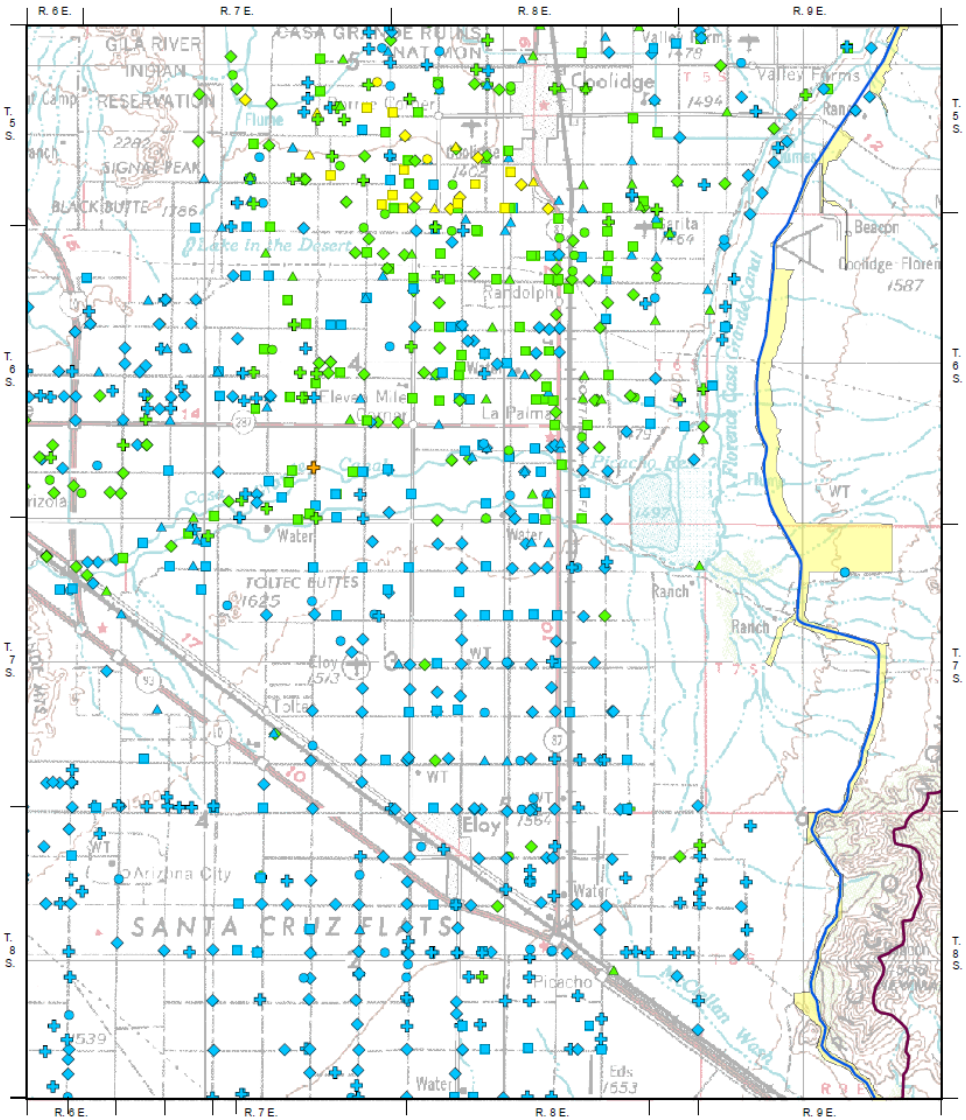
EC in Picacho Basin



EXPLANATION

WELL DEPTH (feet)

- ○ 0 - 100
- △ 101 - 300
- □ 301 - 500
- ◇ 501 - 1,000
- ✚ 1,001 - 5,000
- ▽ Well Depth Unknown

ELECTRICAL CONDUCTIVITY (Estimated TDS Equivalent)

- ● 0 - 1,600 µS/cm (0 - 1,000 mg/L)
- ● 1,601 - 5,000 µS/cm (1,001 - 3,000 mg/L)
- ● 5,001 - 8,000 µS/cm (3,001 - 5,000 mg/L)
- ● 8,001 - 17,000 µS/cm (5,001 - 10,000 mg/L)
- ● > 17,000 µS/cm (>10,000 mg/L)

Picacho Basin Pros / Cons

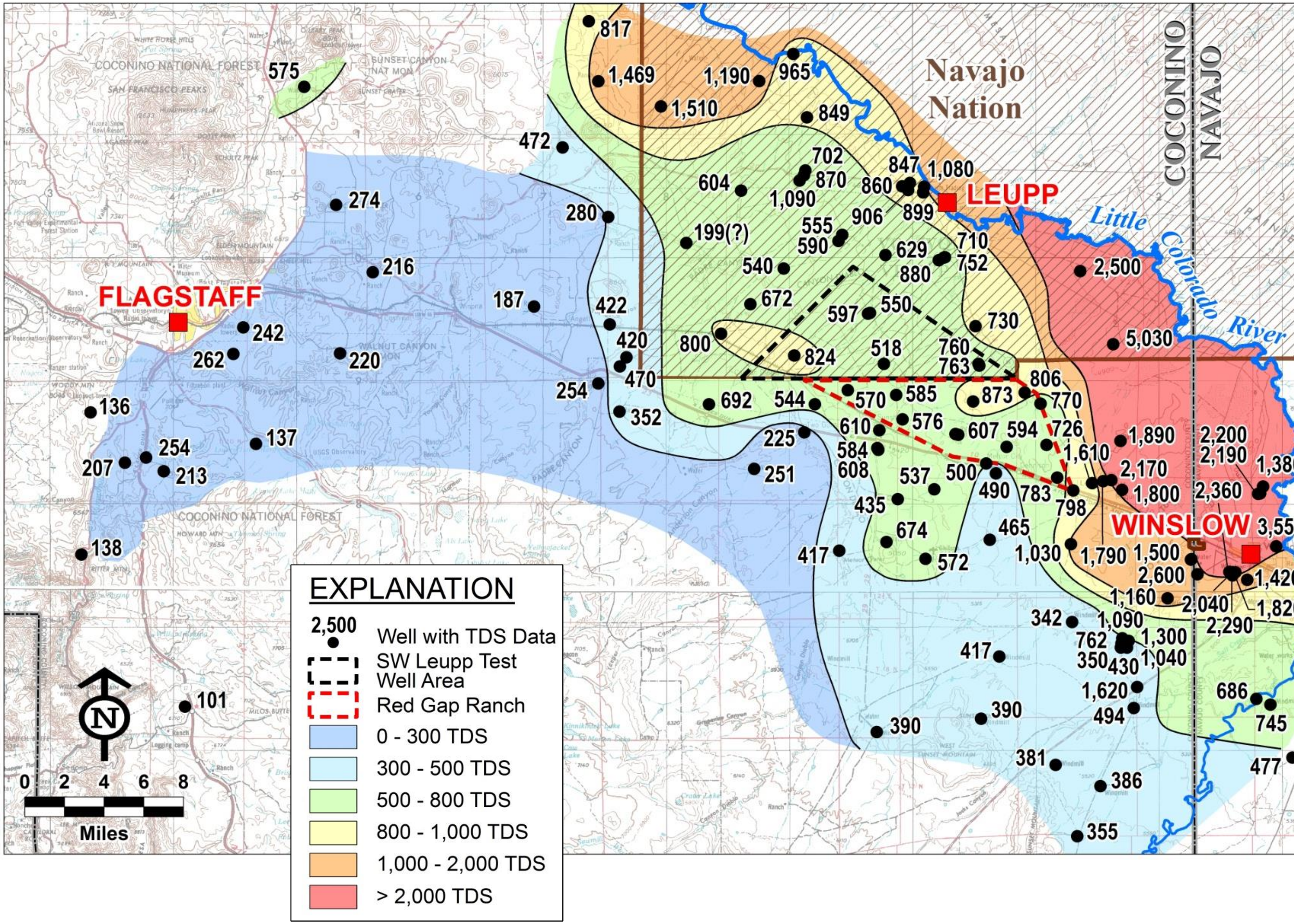
Pros

- Long-term, sustainable supply of brackish groundwater
- Anticipated long-term demand for agricultural supplies, particularly during CAP shortages
- Deep injection may be feasible

Cons

- Recharge of imported CAP water could decrease TDS over time
- Documented subsidence and fissures
- Issues with permitting of deep brine injection

TDS in Winslow – Leupp Area



Winslow-Leupp Area Pros / Cons

Pros

- Significant supply of brackish groundwater
- Good data in some areas from recent testing
- Potential demand from Flagstaff and tribes
- Deep brine disposal potentially feasible

Cons

- Hydrogeologic and water quality conditions are variable
- Water quality may deteriorate and/or change over time
- Issues with permitting of deep brine disposal

Deep Brine Injection Opportunities/Challenges

- All subsurface water currently regulated as a drinking water aquifer in AZ
- APP process already encompasses injection wells
- Current structure provides potential pathways
  - Aquifer declassification
  - Application of existing regulatory structure
    - Use of narrative standards
    - Non-degradation demonstration
    - Protection of existing and foreseeable uses

Deep Brine Injection Opportunities/Challenges

- Permitting and implementation of deep brine injection will require:
  - Robust site conceptual model
  - Significant site characterization efforts
  - Development of reliable model to project aquifer interactions under current and foreseeable future conditions
  - Coordinated efforts between stakeholders
  - Demonstration of technical and economic feasibility

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